POLYLACTIC ACID/THERMOPLASTIC TAPIOCA STARCH BLEND INCORPORATED WITH SELECTED ESSENTIAL OILS FOR ACTIVE FOOD PACKAGING

Adamu Dahiru Ajiya

A thesis submitted in
fulfilment of the requirements for the award of the
Doctor of Philosophy in Science

Faculty of Applied Sciences and Technology
Universiti Tun Hussein Onn Malaysia

February, 2019

Specially dedicated to Allah (SWT) that gave me the strength to undertake this research work and to my parents, my wife, my sisters, all members of Ajiya family and everyone who actively or passively contributed to this work.

ACKNOWLEDGEMENT

I am grateful to Allah Subhanahu Wata'ala (SWT) that gave me the rare opportunity, sustained life and health to carry out this research. My special thanks go to my supervisor, Dr Suzi Salwah Binti Jikan who contributed immensely in guidance and all the assistance required for the progress of the research work. My gratitude goes to Dr Nur Azam Bin Badarulzaman who assisted with technical advice and fabricated the tape casting machine with which TPTS films were made. The contribution of my co-supervisor, Dr Balkis Binti A. Talip is also noted with gratitude. Likewise my second co-supervisor, Dr Darfizzi Derawi who facilitated some of my research work in his laboratory at The University Kebangsaan Malaysia (UKM), his contribution is appreciated. I would like also to acknowledge the contribution of Dr Hazel Monica Mathias-Peralta who provided funds to procure some of the most necessary chemicals for the research at the initial stage.

Most importantly, I would like to express my profound gratitude to all the Academic and non-academic staff of the Faculty of Applied Sciences and Technology who shared their experience with us in exhibitions, workshops and symposiums which eventually shape the research work significantly. My special appreciation to the laboratory technicians who reserved their time to be with us in the laboratory especially, Mr Fazlanuddin, Mr Shahrul, Mr Ishak, Mr Tirmizi, Mr Anuar, Mr Zakariyya Bin Jazuli, Mr Azman, Dr Abdur Rahman and all those whose name have not been stated here. And also appreciation to Aisha Ishaq, Nadia and Liana for their guide in microbiological aspect of the work. I want to express my immense gratitude to all the people of Ajiya family who gave their unreserved support, encouragement and prayers toward the success of this work. All my friends and colleagues in UTHM and ATBU Bauchi and the generality of well-wishers are at this moment appreciated.

ABSTRACT

The environmental effect of petroleum-based polymers and the activity of food spoilage microorganisms made researchers work on alternative bioactive packaging materials. This work aimed at producing sustainable thermoplastic tapioca starch (TPTS) and its polylactic acid (PLA) blend with introduction of antimicrobial (AM) activity via incorporation of lemongrass (LG), lemon balm (LB) and pandan (PA) essential oils (EOs) on the films. The plasticising effect of glycerol and water and compatibilising effect of vinegar loadings on the properties of TPTS were tested. So also the impact of TPTS loading on the PLA/TPTS blend properties. Furthermore, the AM activity of TPTS incorporated with the EOs on *E. coli*, *B. cereus* and *S. marcescens* was evaluated by inhibitory zone; and packaging effect of PLA/TPTS films coated with the EOs on death rate of microorganisms inoculated on *Bahulu* cake was investigated. The TPTS was formed by tape casting method, while PLA/TPTS film by hot pressing. The results indicated an increase in crystallinity and elongation at break with increase in plasticiser loading in TPTS and percentage TPTS loading in PLA/TPTS blend; both were accompanied by a decrease in T_g and tensile strength. Continuous surface morphology was seen at high plasticiser loading in TPTS, while high TPTS loading manifested a phase separation in PLA/TPTS blend. The results show that 125 °C processing temperature, 15 wt% glycerol, 45 wt% water and 3.5 wt% vinegar loading were optimum parameters for TPTS production. Whereas, 185°C processing temperature and 25 wt% TPTS loading are optimum parameters for PLA/TPTS blend production. Citral was found as the common active compound among the EOs. LG and LB were active against all the tested microorganisms, while PA was very mild at higher concentration. For active TPTS and PLA/TPTS films activity, *E. coli*: LB>LG>PA; *B. cereus*: LG>LB>PA; *S. marcescens*: LB>LG>PA. The TPTS and PLA/TPTS active films produced have shown improved properties for food packaging and effective AM activity against the selected microorganisms.

ABSTRAK

Kesan alam sekitar daripada polimer berasaskan petroleum dan aktiviti mikroorganisma yang membinasakan makanan membuat penyelidik bertumpu pada bahan pembungkusan bioaktif alternatif. Kajian ini bertujuan menghasilkan adunan lestari termoplastik kanji ubi kayu (TPTS) dan asid polilaktik (PLA) dengan aktiviti antimikrob (AM) yang diperbaiki menerusi gabungan minyak pati (EOs) *serai* (LG), *lemon balm* (LB) dan *pandan* (PA). Kesan pengekstrakan gliserol dan air dan kesan keserasian kandungan cuka ke atas sifat-sifat TPTS telah diuji. Begitu juga kesan kandungan TPTS pada sifat gabungan PLA/TPTS. Tambahan pula, aktiviti AM TPTS yang digabungkan dengan EOs pada *E. coli*, *B. cereus* dan *S. marcescens* dinilai oleh zon penghalang; dan kesan pembungkusan filem PLA/TPTS yang disalut dengan EOs pada kadar kematian mikroorganisma yang diumpukkan pada kek Bahulu telah disiasat. TPTS terhasil menerusi kaedah tuangan pita, manakala filem PLA/TPTS terhasil menerusi penekanan panas. Hasil dapatan menunjukkan peningkatan dalam kehabluran dan pemanjangan patah dengan pertambahan kandungan pemplastik dalam TPTS serta peratus kandungan TPTS dalam adunan PLA/TPTS, kedua-duanya dituruti dengan pengurangan T_g dan kekuatan tegangan. Morfologi permukaan yang berterusan dilihat pada kandungan pemplastik yang tinggi dalam TPTS, manakala kandungan TPTS yang tinggi menunjukkan pemisahan fasa dalam adunan PLA/TPTS. Keputusan menunjukkan bahawa pada suhu pemprosesan 125°C, 15 wt% berat gliserol, 45 wt% air dan 3.5 wt% cuka adalah parameter optimum untuk pengeluaran TPTS. Sementara itu, suhu pemprosesan 185 °C dan 25 wt% TPTS adalah parameter optimum untuk pengeluaran PLA/TPTS. Citral dijumpai sebagai sebatian aktif yang biasa di kalangan EOs. LG dan LB aktif terhadap semua mikroorganisma yang diuji, sementara PA kurang berkesan pada kepekatan yang lebih tinggi. Untuk aktiviti filem aktif TPTS dan PLA/TPTS, *E. coli*: LB>LG>PA; *B. cereus*: LG>LB>PA; *S. marcescens*: LB>LG>PA. Filem aktif TPTS dan PLA/TPTS yang terhasil telah menunjukkan sifat yang dipertingkatkan sebagai pembungkus makanan dan aktiviti AM berkesan terhadap mikroorganisma terpilih.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

μ	-	death rate
α	-	Alpha crystalline structure
ε	-	Elongation at break (%)
σ	-	Tensile stress (MPa)
°C	-	Degree Celsius
μm	-	Micrometre
ANOVA	-	Analysis of variance
Au × nm	-	Area under curve × nanometer
ASTM	-	American society for testing and materials
BCM	-	Bacillus cereus medium
CEN	-	European standardisation committee
DIN	-	German institute for standardisation
DMA	-	Dynamic mechanical analysis
DSC	-	Differential scanning calorimetry
DTG	-	Derivative thermogravimetry
E’	-	Storage elastic modulus
E”	-	Loss viscous modulus
EMB	-	Eosin methylene blue
FTIR	-	Fourier transform infrared
g	-	gram
GCMS	-	Gas chromatography mass spectrometry
HPMC	-	Hydroxypropyl methyl cellulose
ISO	-	International Standards Organisation
LAB	-	Lactic acid bacteria
MBC	-	Minimum bactericidal concentration
MIC	-	Minimum inhibition concentration
min	-	minute

mm	-	millimeter
N	-	Population
NA	-	Nutrient agar
NB	-	Nutrient Broth
ORCA	-	Organic reclamation and composting association
PDA	-	Potatoes dextrose agar
PLA	-	Polylactic acid
PVC	-	Polyvinyl chloride
rpm	-	Revolution per minute
s	-	second
SEM	-	Scanning electron microscopy
t	-	Time
Tan δ	-	Damping coefficient
T_g	-	Glass transition temperature
TGA	-	Thermogravimetric analysis
T_m	-	Melting temperature
TPS	-	Thermoplastic starch
TPTS	-	Thermoplastic tapioca starch
XLD	-	Xylose lysine deoxy-cholate
XRD	-	X -ray diffraction
UV	-	Ultraviolet

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Research background

The plastics have immense importance in modern life; its function is universal ranging from household articles, self-healing materials, clothes, shoes, packaging, up to auto parts. The primary source of plastics is the fossil fuel. The increased change of petroleum resource price in the 1970s extend the consciousness of researchers toward alternative sources for plastics, which is one of the significant products of fossil fuel (Wittcoff *et al.*, 2013). The rate of depletion of fossil fuel is among other factors of concern (Pervaiz *et al.*, 2014). This limited resource is bound to finish in the midst of an uneven price system. It is forecasted that fossil fuel will be depleted averagely by 2100 if the current rate of consumption is maintained (IEA, 2017). Secondly, the environmental pollution caused by the excessive volume of non-biodegradable plastic waste materials poses a threat to life and wellbeing of the environment. This issue is coupled with inadequate landfill space for disposal, the high maintenance cost of landfill, and non-degradability of the plastics for about a thousand years (Cressey, 2016).

The cumulative amount of plastics produced globally between 1950 and 2015 was around 7.82 billion tonnes. Most of these products were used in the field of packaging. One unique characteristic of plastic packaging is that it is used once after which it is discarded, particularly the food packaging where contamination by the microorganisms is involved (Geyer *et al.*, 2017). By 2015 the packaging sector accounted for 42 % (141 million tonnes) of global plastic produced. While during the same period, packaging constituted about 50 % of global plastic waste (Hannah & Max, 2018).

In Malaysia a similar trend was observed, packaging constituted 45 % of plastics produced. Also, about 24 % of municipal solid waste is made of plastic materials, even though, the percentage of packaging material was not quantified (Zainua & Songip, 2017). But research shows that about 22-55 billion shopping bags are sold per year in Malaysia (Sung, 2017). This activity constitutes a major environmental concern because only 5 % of the plastics are recycled, 42 % of the municipal waste is incinerated which brings about air pollution. On the other hand, the rest of the 53 % are dumped in landfills, and the plastics in this category does not degrade quickly, destroying the environment in open landfills (Zainua & Songip, 2017). Disposable food package provides the benefit and convenience of one time, sanitary use. Thin films used in such products are typically made from water-insoluble synthetic polymers or polymer blends. However, the disposal of these products is a concern due to limited landfill space. Incineration of such products is not desirable because of increasing alarm about greenhouse gases generation. Consequently, there is a need for bio-degradable products which may be quickly and conveniently disposed of without dumping or incineration (Gabor & Tita, 2012). It has been proven by series of researches (Iwate, 2015; Roshafima *et al.*, 2012; Seligra *et al.*, 2016) that petroleum-based plastics degrade eventually, but that process usually takes a very long time and contribute to global warming through the release of carbon dioxide and methane gas. Therefore, research in alternative renewable, biodegradable, eco-friendly and cost-effective raw material for the production of plastics flourish.

Biodegradable plastics are made out of ingredients that can be metabolised by naturally occurring micro-organisms in the environment. Bio-degradable films and coatings have been mainly considered in food preservation, because of their capability for improving global food quality (McKeen, 2012). Recently, innovative ways to inhibit microbial growth in the foods while maintaining quality, freshness, and safety have been investigated. One option is the use of packaging to provide protection, quality and longer shelf life (Priyaa *et al.*, 2014). Packaging is the most significant process aimed at giving the stable condition of food products for their storage, transportation, distribution, and consumption. The primary function of packaging is protection from mechanical damage and prevention or inhibition of chemical changes, biochemical changes and microbiological spoilage (Biron, 2007). Food products during packaging can be subjected to various type of contaminations including microbial contamination that is mainly caused by bacteria, yeasts and mould (Malhotra *et al.*, 2015; Prasad & Kochhar, 2014). Specifically, food products are sensitive and their shelf life is limited by their interaction with packaging materials that can alter their water activity, pH, added preservatives and also substances that can affect their temperature, relative humidity, light and gas composition (Lucera *et al.*, 2016; Miranda *et al.*, 2016). One of the significant possibility to extend the shelf life of the products is to develop packaging material with specific properties such as pH, water activity, respiration rate and existence of antimicrobial compounds which is referred to as bioactive packaging material and can be used to improve the quality of food products and to extend their shelf life (Du *et al.*, 2011). In food packaging, the goal is to use bioactive materials to get a desirable response, for example, the inhibition of microbial growth, barrier adjusting materials, as well as flavour maintenance and enhancing material properties. Most bio-based materials such as polysaccharides and protein-based polymers (starch, cellulose, alginate, collagen, gelatin, and proteins) are hydrophilic with a relatively high degree of crystallinity causing processing and performance difficulties. Therefore, antimicrobial (AM) packages made from such bio-based films demonstrate high moisture sensitivity, poor water barrier and poor mechanical properties compared to those made from synthetic polymers such as polyvinyl chloride (PVC), polypropylene (PP) and polyethylene terephthalate (PET) (Roshafima *et al.*, 2012). Packaging materials with suitable physicomechanical properties can be prepared from biopolymers such as starch-based materials when the contents are modified by physical, mechanical and chemical techniques or by blending with compatible plasticisers (McKeen, 2012).

The production of starch globally was estimated to be around 75 million tons in 2012, where maize, tapioca (cassava), wheat and potato were the major plants for starch production with an amount of rice and other starches being produced (Waterschoot *et al.*, 2015). Tapioca starch global production was estimated to reach a volume of 6.7 million tons, and the report forecast a 1.6 % growth annually where it will be 7.4 million tons by 2023 (IMARC, 2018). It was reported that Malaysia grows about 400,000 tonnes/year of tapioca, which is large enough to earn a sustainable income to farmers, and provide raw materials to the industries (Hillocks *et al.*, 2002; UFAO, 2012). But another report shows that Malaysia's tapioca production in 2016 stood at 77,980 tonnes declining from 400,000 tonnes in 1989 due to market and other factors (Factfish, 2017).

REFERENCES

Abdellatif, F., Boudjella, H., Zitouni, A., & Hassani, A. (2014). Chemical Composition and antimicrobial activity of the essential oil from leaves of Algerian Melissa Officinalis. *EXCLI Journal, 13*, 772-781

Acevedo-Fani, A., Salvia-Trujillo, L., Rojas-Graü, M. A., & Martín-Belloso, O. (2015). Edible films from essential-oil-loaded nanoemulsions: Physicochemical characterization and antimicrobial properties. *Food Hydrocolloids, 47*, 168-177

Adinee, J., Piri, K., & Karami, O. (2009). Essential Oil Composition of Lemon Balm (Melissa officinalis L.) Leaves Grown in Hamadan Province, Iran. *Medicinal and Aromatic Plant Science and Biotechnology*

Adukwu, E. C., Bowles, M., Edwards-Jones, V., & Bone, H. (2016). Antimicrobial activity, cytotoxicity and chemical analysis of lemongrass essential oil (Cymbopogon flexuosus) and pure citral. *Appl Microbiol Biotechnol, 100*(22), 9619-9627

Adukwu, E. C., Bowles, M., Edwards-Jones, V., & Bone, H. (2016). Antimicrobial activity, cytotoxicity and chemical analysis of lemongrass essential oil (Cymbopogon flexuosus) and pure citral. *Applied Microbiology and Biotechnology, 100*(22), 9619-9627

Ahmad, A., & Viljoen, A. (2015). The in vitro antimicrobial activity of Cymbopogon essential oil (lemon grass) and its interaction with silver ions. *Phytomedicine, 22*(6), 657-665

Ahvenainen, P., Kontro, I., & Svedström, K. (2016). Comparison of sample crystallinity determination methods by X-ray diffraction for challenging cellulose I materials. *Cellulose*, *23*(2), 1073-1086

Akhila, A. (2010). Chemistry and Biogenesis of Essential Oils from the Genus Cymbopogon. *New York: Taylor and Francis group, LLC*, 69

Akrami, M., Ghasemi, I., Azizi, H., Karrabi, M., & Seyedabadi, M. (2016). A new approach in compatibilization of the poly(lactic acid)/thermoplastic starch (PLA/TPS) blends. *Carbohydr Polym, 144*, 254-262

Albayrak, S., Aksoy, A., Albayrak, S., & Sagdic, O. (2013). In vitro antioxidant and antimicrobial activity of some Lamiaceae species. *IJST, A1*, 1-9

Alboofetileh, M., Rezaei, M., Hosseini, H., & Abdollahi, M. (2014). Antimicrobial activity of alginate/clay nanocomposite films enriched with essential oils against three common foodborne pathogens. *Food Control, 36*(1), 1-7

Alrumman, S. A. (2016). Enzymatic saccharification and fermentation of cellulosic date palm wastes to glucose and lactic acid. *Braz J Microbiol, 47*(1), 110-119

Alshehrei, F. (2017). Biodegradation of Synthetic and Natural Plastic by Microorganisms. *Journal of Applied & Environmental Microbiology, 5*(1), 8-19

Ander, O., M Angeles Corcuera, Pen, C., Eceiza, A., & Arbelaiz, A. (2014). Bionanocomposites based on thermoplastic starch and cellulose nanofibers. *Journal of Thermoplastic Composite Materials & Design*, 1-16

Anon. (1988). Glossary of packaging terms *The Packaging Institute International Stanford Connecticut*.

Arboleda, G. A., Montilla, C. E., Villada, H. S., & Varona, G. A. (2015). Obtaining a Flexible Film Elaborated from Cassava Thermoplastic Starch and Polylactic Acid. *International Journal of Polymer Science, 2015*, 1-9

ASTM-D-882. (2012). Standard test Method for Tensile properties of thin plastic sheeting significance and use.

ASTM-D-3418. (1999). Standard Test Method for Transition Temperatures of Polymers By Differential Scanning Calorimetry.

ASTM-D-5338-98. (2003). Standard Test Method for Determining Aerobic Biodegradation of Plastic Materials Under Controlled Composting Conditions. 1-6

Attaran, S. A., Hassan, A., & Wahit, M. U. (2015). Materials for food packaging applications based on bio-based polymer nanocomposites. *Journal of Thermoplastic Composite Materials, 30*(2), 143-173

Averous, L., & Boquillon, N. (2004). Biocomposites based on plasticized starch: thermal and mechanical behaviours. *Carbohydr Polym, 56*(2), 111-122

Ayana, B., Suin, S., & Khatua, B. B. (2014). Highly exfoliated eco-friendly thermoplastic starch (TPS)/poly (lactic acid)(PLA)/clay nanocomposites using unmodified nanoclay. *Carbohydr Polym*, *110*, 430-439

Bachrouri, M., Quinto, E. J., & Mora, M. T. (2002). Survival of Escherichia Coli O157:H7 During Storage of Yogurt at Different Temperatures. *Journal of Food Science*, *6*(5)

Balakrishnan, P., Sreekala, M. S., Kunaver, M., Huskic, M., & Thomas, S. (2017). Morphology, transport characteristics and viscoelastic polymer chain confinement in nanocomposites based on thermoplastic potato starch and cellulose nanofibers from pineapple leaf. *Carbohydr Polym*, *169*, 176-188

Bastarrachea, L. J., Dana, E. W., Maxine, J. R., Lin, Z., & Julie, M. G. (2015). Active packaging Coatings. *Coatings*, *5*, 771-791

Bastioli, C. (1998). Biodegradable materials Present situation and future perspective. *Macromol. Symp.*, *135*, 193-204

Bensebaa, F. (2013). Chapter 4 - Nanoparticle Assembling and System Integration. In F. Bensebaa (Ed.), *Interface Science and Technology* (Vol. 19, pp. 185-277): Elsevier.

Bergo, P., Sobral, P. J. A., & Prison, J. M. (2010). Effect of Glycerol on Physical Properties of Cassava Starch Films. *Journal of Food Processing and Preservation*, *34*, 401-410

Bergo, P. V. A., Carvalho, R. A., Sobral, P. J. A., dos Santos, R. M. C., da Silva, F. B. R., Prison, J. M., Solorza-Feria, J., & Habitante, A. M. Q. B. (2008). Physical properties of edible films based on cassava starch as affected by the plasticizer concentration. *Packaging Technology and Science*, *21*(2), 85-89

Bhosle, S. M., & Friedrich, C. R. (2017). Facile Synthesis of Nanosilver-Incorporated Titanium Nanotube for Antibacterial Surfaces. *Journal of Bio- and Tribo-Corrosion*, *3*(3)

Bibhu, P. S., Panchanan, G., & Chakrapani, P. (2016). Pandanus Odaritissimus Linn: Isolation of Stigmast-5, 22-dien-3β-ol from Ethanolic Extract of Stem Bark and Study of Antimicrobial Activity. *Journal of Chemistry and Chemical Sciences*, *6*(6), 574-585

Bilal, D., Ali, Y., & Hüseyin, E. (2011). Crystallization Behavior of PET Materials. *BAÜ Fen Bil. Enst. Dergisi Cilt*, *13*(1), 26-35

Biron, M. (2007). *Thermoplastics and Thermoplastic Composites Technical Information for Plastics Users*: Elsevier Science.

Bonferoni, M. C., Sandri, G., Rossi, S., Usai, D., Liakos, I., Garzoni, A., Fiamma, M., Zanetti, S., Athanassiou, A., Caramella, C., & Ferrari, F. (2017). A novel ionic amphiphilic chitosan derivative as a stabilizer of nanoemulsions: Improvement of antimicrobial activity of Cymbopogon citratus essential oil. *Colloids Surf B Biointerfaces, 152*, 385-392

Boyce, J. M. (2018). Alcohols as Surface Disinfectants in Healthcare Settings. *Infect Control Hosp Epidemiol, 39*(3), 323-328

BSAC. (2014). BSAC-disc-susceptibility-testing-method. (13)

Burt, S. (2004). Essential oils: their antibacterial properties and potential applications in foods--a review. *Int J Food Microbiol, 94*(3), 223-253

Byun, Y., Zhang, Y., & Gen, X. (2014). Plasticization and Polymer Morphology, *Innovations in Food Packaging* (pp. 87-109): Elsevier Ltd.

Carraher, C. E. J. (2011). *Polymer Chemistry* (8th ed.). US: CRC Press, Taylor & Francis.

Cetin-Karaca, H., & Newman, M. C. (2015). Antimicrobial efficacy of plant phenolic compounds against Salmonella and Escherichia Coli. *Food Bioscience, 11*, 8-16

Chang, Y. P., Cheah, P. B., & Seow, C. C. (2000). Plasticizing-Antiplasticizing Effects of Water on Physical Properties of Tapioca Starch Films in the Glassy State. *Journal of Food Science, 65*(3), 445-453

Chauhan, S. K., Kumar, R., & Nadanasabapathi, S. (2017). Turbidimetric Assay of Nisin in Tender Coconut Water. *Defence Life Science Journal, 2*(2), 212

Chen, Q., Yu, H., Wang, L., ul Abdin, Z., Chen, Y., Wang, J., Zhou, W., Yang, X., Khan, R. U., Zhang, H., & Chen, X. (2015). Recent progress in chemical modification of starch and its applications. *RSC Advances, 5*(83), 67459-67474

Chen, X. K., & Ge, F. H. (2014). Chemical components from essential oil of Pandanus amaryllifolius leaves. *Journal of Chinese Medicinal Materials, 37*(4), 616-620

Chieng, B. W., Ibrahim, N. A., Then, Y. Y., & Loo, Y. Y. (2014). Epoxidized vegetable oils plasticized poly(lactic acid) biocomposites: mechanical, thermal and morphology properties. *Molecules, 19*(10), 16024-16038

Combrzynski, M., Moscicki, L., Rejak, A., Wojtowicz, A., & Oniszczuk, T. (2013). Selected mechanical properties of starch film. *TekaCommission of Motorisationand Energetics in Agriculture, 13*(2), 7-12

Cortes, H., Edgar, V., Suárez, R., Castillo, J., Gonçalves, L. M., & Bueno, P. R. (2014). Pitahaya Aging Diagnostic by Impedance/Capacitance Spectroscopy. *Food Analytical Methods, 8*(1), 126-129

Cressey, D. (2016). The Plastic Ocean (Vol. 536, pp. 263-265). London: Nature.

Da Róz, A. L., Veiga-Santos, P., Ferreira, A. M., Antunes, T. C. R., Leite, F. d. L., Yamaji, F. M., & Carvalho, A. J. F. d. (2016). Water Susceptibility and Mechanical Properties of Thermoplastic Starch–Pectin Blends Reactively Extruded with Edible Citric Acid. *Materials Research, 19*(1), 138-142

Dang, K. M., & Yoksan, R. (2015). Development of thermoplastic starch blown film by incorporating plasticized chitosan. *Carbohydr Polym, 115*, 575–581

Dang, K. M., & Yoksan, R. (2016). Morphological characteristics and barrier properties of thermoplastic starch/chitosan blown film. *Carbohydr Polym, 150*, 40-47

Dashipour, A., Razavilar, V., Hosseini, H., Shojaee-Aliabadi, S., German, J. B., Ghanati, K., Khakpour, M., & Khaksar, R. (2015). Antioxidant and antimicrobial carboxymethyl cellulose films containing Zataria multiflora essential oil. *Int J Biol Macromol, 72*, 606-613

Day, B. P. F. (2001). Active Packaging brand – a fresh approach. *the journal of brand technology, 1* (1), 32–41

Day, B. P. F. (2008). Active Packaging of Food. In J. Kerry & P. Butler (Eds.), *Smart Packaging Technologies for fast moving consumer goods* (pp. 1-17). UK: John Wiley & Sons, Ltd.

Day, B. P. F., & Potter, L. (2011). Active Packaging. In C. Richard & K. Mark (Eds.), *Food and Beverage Packaging Technology* (Second ed.). UK: Blackwell Publishing Ltd. .

de Moraes, J. O., Scheibe, A. S., A., B., C., M., & Laurindo, J. B. (2015). Conductive drying of starch-fiber films prepared by tape casting: Drying rates and film properties. *LWT - Food Science and Technology, 64*(1), 356-366

de Moraes, J. O., Scheibe, A. S., Sereno, A., & Laurindo, J. B. (2013). Scale-up of the production of cassava starch based films using tape-casting. *Journal of Food Engineering, 119*(4), 800-808

Detduangchan, N., Sridach, W., & Wittaya, T. (2014). Enhancement of the properties of biodegradable rice starch films by using chemical crosslinking agents. *International Food Research Journal, 2*(3), 1225-1235

Ding, C., Zhang, M., & Li, G. (2015). Preparation and characterization of collagen/hydroxypropyl methylcellulose (HPMC) blend film. *Carbohydr Polym, 119*, 194–201

Du, W.-X., Roberto, J. A.-B., Hua, S. S. T., & McHugh, T. H. (2011). Antimicrobial volatile essential oils in edible films for food safety. *Science against microbial pathogens: communicating current research and technological advanc, 1124-1135*

Dumaoal, O. S. R., Alaras, L. B., Karen G. Dahilan, Depadua, S. A. A., & Pulmone, C. J. G. (2010). In Vitro Activity of Pandan (Pandanus amaryllifolius) Leaves Crude Extract Against Selected Bacterial Isolates. *JPAIR Multidisciplinary Journal*, 102-124

Ebrahimi, H., Afshar Najafi, F. S., Shahabadi, S. I. S., & Garmabi, H. (2015). A response surface study on microstructure and mechanical properties of poly(lactic acid)/thermoplastic starch/nanoclay nanocomposites. *Journal of Composite Materials, 50*(2), 269-278

Edwin, S. M., Leornard, G., & Elijah, G. (2012). Isolation And Identification Of Essential Oils From Cymbopogan Citratus (Stapf) Dc Using Gc-Ms And Ft-Ir. *Chemistry and Materials Research, 2*(4), 13

Emiroğlu, Z. K., Yemiş, G. P., Coşkun, B. K., & Candoğan, K. (2010). Antimicrobial activity of soy edible films incorporated with thyme and oregano essential oils on fresh ground beef patties. *Meat Science, 86*, 283–288

Enil Klarmann, Vladimira, A. S., & Gates, L. W. (1933). The Alkyl Derivatives of Halogen Phenols and their Bactericidal Action. I. Chlorophenols. *J. Bacteriol.,, 17*(437)

Factfish. (2017). Malaysia: Cassava, production quantity (tons) http://www.factfish.com/statistic- country/malaysia/cassava,+production+quantity.

Falcão, M. A., Fianco, A. L. B., Lucas, A. M., Pereira, M. A. A., Torres, F. C., Vargas, R. M. F., & Cassel, E. (2012). Determination of antibacterial activity of vacuum distillation fractions of lemongrass essential oil. *Phytochemistry Reviews, 11*(4), 405-412

Fu, X., Feng, F., & Huang, B. (2006). Physicochemical characterization and evaluation of a microemulsion system for antimicrobial activity of glycerol monolaurate. *Int J Pharm, 321*(1-2), 171-175

Fu, Z.-q., Wang, L.-j., Li, D., Wei, Q., & Adhikari, B. (2011). Effects of high-pressure homogenization on the properties of starch-plasticizer dispersions and their films. *Carbohydr Polym, 86*(1), 202-207

Gabor, D., & Tita, O. (2012). Biopolymers used in Food Packaging: A Review. *Acta Universitatis Cibiniensis Series E: Food Technology, 16*(2), 1-17

Gao, C., Pollet, E., & Averous, L. (2017). Innovative plasticized alginate obtained by thermo-mechanical mixing: Effect of different biobased polyols systems. *Carbohydr Polym, 157*, 669-676

García, N. L., L., R., A., D., M., A., & S., G. (2011). Effect of glycerol on the morphology of nanocomposites made from thermoplastic starch and starch nanocrystals. *Carbohydr Polym, 84*(1), 203-210

García, N. L., Ribba, L., Dufresne, A., Aranguren, I. M., & Goyanes, S. (2009). Physico-Mechanical Properties of Biodegradable Starch Nanocomposites. *Macromolecular Materials and Engineering, 294*(3), 169-177

Gardini, D., Deluca, M., Nagliati, M., & Galassi, C. (2010). Flow properties of PLZTN aqueous suspensions for tape casting. *Ceramics International, 36*(5), 1687-1696

Garlotta, D. (2001). A Literature Review of Poly(Lactic Acid). *Journal of Polymers and the Environment, 9*(2), 63-85

Georgieva, R., Yocheva, L., Tserovska, L., Zhelezova, G., Stefanova, N., Atanasova, A., Danguleva, A., Ivanova, G., Karapetkov, N., Rumyan, N., & Karaivanova, E. (2015). Antimicrobial activity and antibiotic susceptibility of Lactobacillus and Bifidobacterium spp. intended for use as starter and probiotic cultures. *Biotechnol Biotechnol Equip, 29*(1), 84-91

Geyer, R., Jambeck, J. R., & Law, K. L. (2017). Production, use and fate of all plastics ever made. *Science Advances, 3*(7)

Ghabraie, M., Vu, K. D., Tata, L., Salmieri, S., & Lacroix, M. (2016). Antimicrobial effect of essential oils in combinations against five bacteria and their effect on sensorial quality of ground meat. *LWT - Food Science and Technology, 66*, 332-339

Ghasemlou, M., Aliheidari, N., Fahmi, R., Shojaee-Aliabadi, S., Keshavarz, B., Cran, M. J., & Khaksar, R. (2013). Physical, mechanical and barrier properties of corn starch films incorporated with plant essential oils. *Carbohydr Polym, 98*(1), 1117-1126

Gill, P., Tohidi Moghadam, T., & Ranjbar, B. ((2010)). Differential Scanning Calorimetry Techniques: Applications in Biology and Nanoscience. *Journal of Biomolecular Techniques*(21), 167–193

Goldstein, J. I., Dale, E. N., Joseph, R. M., Nicholas, W. M. R., John, H. J. S., & David, C. J. (2017). *Scanning Electron Microscopy and X-Ray Microanalysis* (Vol. 4). Newyork, USA: Springer.

Gontard, N., Guilbert, S., & Cuq, J.-L. (1993). Water and Glycerol as Plasticizers Affect Mechanical and Water Vapor Barrier Properties of an Edible Wheat Gluten Film. *Journal of Food Science, 58*(1), 206-212

Guo, M., Jin, T. Z., & Yang, R. (2014). Antimicrobial Polylactic Acid Packaging Films against Listeria and Salmonella in Culture Medium and on Ready-to-Eat Meat. *Food and Bioprocess Technology, 7*(11), 3293-3307

Gurmeet, S., & Amrita, P. (2015). Unique pandanus - Flavour, food and medicine. *Journal of Pharmacognosy and Phytochemistry, 5*(3), 8-14

Gyawali, R., & Ibrahim, S. A. (2014). Natural products as antimicrobial agents. *Food Control, 46*, 412-429

Han, J. H., & Floros, J. D. (1997). Casting Antimicrobial Packaging Films and Measuring Their Physical Properties and Antimicrobial Activity. *Journal of Plastic Film and Sheeting, 13*, 287-298

Hannah, R., & Max, R. (2018). "Plastic Pollution". Retrieved 10/12/2018, from 'https://ourworldindata.org/plastic-pollution'.

Heras-Mozos, R., Muriel-Galet, V., López-Carballo, G., Catalá, R., Pilar, H.-M., & Rafael, G. (2019). Development and optimization of antifungal packaging for sliced pan loaf based on garlic as active agent and bread aroma as aroma corrector. *Int J Food Microbiol, 290* 42–48

Hillocks, R. J., Thresh, J. M., & Bellotti, A. C. (2002). *Cassava Biology, Production and Utilization,* : CAB International Wallingford, UK

Hou, C., Chen, Y., Chen, W., & Li, W. (2011). Microwave-assisted methylation of cassava starch with dimethyl carbonate. *Carbohydr Res, 346*(9), 1178-1181

Ibrahim, N., Mohamad, K. A. W., Du, N. U., & Hanafi, I. (2017). Physical and Degradation Properties of Polylactic Acid and Thermoplastic Starch Blends – Effect of Citric Acid Treatment on Starch Structures. *BioResources, 12*(2), 3076-3087

IEA. (2017). World Energy Outlook (WEO-2017) International Energy Agency https://www.iea.org/statistics.

IMARC. (2018). Global Cassava (Tapioca) Starch Market Overview 2018, Demand by Regions, Share, Price Trends and Forecast to 2023.

Imre, B., & Pukanszky, B. (2013). Compatibilization in bio-based and biodegradable polymer blends. *European Polymer Journal, 49*, 1215 –1233

ISO-1666. (1996). Starch - Determination of moisture content - Oven drying method

ISO-14855-1. (2012). Determination of the ultimate aerobic biodegradability of plastic materials under controlled composting conditions. Method by analysis of evolved carbon dioxide. General method.

Issaadi, K., Habi, A., Grohens, Y., & Pillin, I. (2015). Effect of the montmorillonite intercalant and anhydride maleic grafting on polylactic acid structure and properties. *Applied Clay Science, 107*, 62-69

Ivanic, F., Jochec-Moskova, D., Janigova, I., & Chodak, I. (2017). Physical properties of starch plasticized by a mixture of plasticizers. *European Polymer Journal, 93*, 843-849

Iwate, T. (2015). Biodegradable and Biobased Polymers: Future prospects of Eco-Friendly Plastics. *Angew. Chem. Int. Ed., 54*, 2 – 8

Jafari, N. K., & Sani, A. M. (2016). Chemical composition and antibacterial activity of essential oil from *Melissa officinalis* leaves. *ARPN Journal of Agricultural and Biological Scienc, 11*(9), 367-372

Jaramillo, C. M., Gutierrez, T. J., Goyanes, S., Bernal, C., & Fama, L. (2016). Biodegradability and plasticizing effect of yerba mate extract on cassava starch edible films. *Carbohydr Polym, 151*, 150-159

Jeannine, B. L., Nıvea, M. V., Rodolfo, M. C. D. S., Ana, M. Q. B. B., & Paulo, J. A. S. (2015). Mechanical properties of cassava starch films as affected bydifferent plasticizers and different relative humidity conditions. *International Journal of Food Studies, 4*, 116–125

Jeroen, J. G., Soest, v., Hulleman, S. H. D., Wit, D. d., & Vliegenthart, J. F. G. (1996). Crystallinity in starch bioplastics. *Industrial Crops and Products, 5*, 11-22

Jesionek, W., Majer-Dziedzic, B., & Choma, I. M. (2017). TLC–direct bioautography as a method for evaluation of antibacterial properties of Thymus vulgaris L. and Salvia officinalis L. essential oils of different origin. *Journal of Liquid Chromatography & Related Technologies, 40*(5-6), 292-296

Jideani, V. A., & Vogt, K. (2016). Antimicrobial Packaging for Extending the Shelf Life of Bread-A Review. *Crit Rev Food Sci Nutr, 56*(8), 1313-1324

Jiugao, Y., Ning, W., & Xiaofei, M. (2005). The Effects of Citric Acid on the Properties of Thermoplastic Starch Plasticized by Glycerol. *Starch - Stärke, 57*(10), 494-504

Johnston, B., Jiang, G., Hill, D., Adamus, G., Kwiecien, I., Zieba, M., Sikorska, W., Green, M., Kowalczuk, M., & Radecka, I. (2017). The Molecular Level Characterization of Biodegradable Polymers Originated from Polyethylene Using Non-Oxygenated Polyethylene Wax as a Carbon Source for Polyhydroxyalkanoate Production. *Bioengineering (Basel), 4*(3)

Juansang, J., Puncha-Arnon, S., Uttapap, D., Puttanlek, C., Rungsardthong, V., & Watcharatewinkul, Y. (2017). Concentration of plasticizers applied during heat-moisture treatment affects properties of the modified canna starch. *Food Chem, 221*, 1587-1594

Kaewtatip, K., & Thongmee, J. (2013). Effect of kraft lignin and esterified lignin on the properties of thermoplastic starch. *Materials & Design, 49,* 701-704

Katz, F. (1998). New research in packaging *Food Technol, 52*, 56

Ke, T., & Sun, X. (2003). Melting Behavior and Crystallization Kinetics of Starch and Poly(lactic acid) Composites. *Journal of Applied Polymer Science,, 89*, 1203–1210

Khankrua, R., Pivsa-Art, S., Hiroyuki, H., & Suttiruengwong, S. (2014). Effect of chain extenders on thermal and mechanical properties of poly(lactic acid) at high processing temperatures: Potential application in PLA/Polyamide 6 blend. *Polymer Degradation and Stability, 108*, 232-240

Kizkitza, G., Retegia, A., Alba, G., Arantxa, E., & Nagore, G. (2015). Starch and cellulose nanocrystals together into thermoplastic starch bionanocomposites. *Carbohydr Polym, 117,* 83–90

Klangmuang, P., & Sothornvit, R. (2016). Barrier properties, mechanical properties and antimicrobial activity of hydroxypropyl methylcellulose-based nanocomposite films incorporated with Thai essential oils. *Food Hydrocolloids, 61*, 609-616

Kodre, K., Attarde, S., Yendhe, P., Patil, R., & Barge, V. (2014). Differential Scanning Calorimetry: A Review. *Journal of Pharmaceutical Analysis, 3*(3), 11-22

Kong, X., Zhu, P., Sui, Z., & Bao, J. (2015). Physicochemical properties of starches from diverse rice cultivars varying in apparent amylose content and gelatinisation temperature combinations. *Food Chemistry, 172*, 433–440

Kumar, P. M., Irina, A., & Manjeet, S. C. (2002). Modeling water vapour, gas and solute transport through protein films. In A. Gennadios (Ed.), *Protein Based Films And Coatings* (pp. 329-337). New York, USA: CRC Press.

Kumar, S. V., Sajeevkumar, V. A., & Sunny, K. (2018). The influence of bound water on the FTIR characteristics of starch and starch nanocrystals obtained from selected natural sources†. *Starch - Stärke*

Kuorwel, K. K., Cran, M. J., Sonneveld, K., Miltz, J., & Bigger, S. W. (2011). Antimicrobial activity of biodegradable polysaccharide and protein-based films containing active agents. *J Food Sci, 76*(3), R90-R102

Kuorwel, K. K., Cran, M. J., Sonneveld, K., Miltz, J., & Bigger, S. W. (2013). Migration of antimicrobial agents from starch-based films into a food simulant. *LWT - Food Science and Technology, 50*(2), 432-438

Leire, S., Jordana, K. P., Mercedes, F., José Ignacio, E., Antxon, S., & Alejandro, J. M. (2016). Linear and non-linear rheological behavior of polypropylene_polyamide blends modified with a compatibilizer agent and nanosilica and its relationship with the morphology. *European Polymer Journal, 83*(10-21)

Leon, P. B. M. J., & Leszek, M. (2009). Thermoplastic Starch A Green Material for Various Industries. In P. B. M. J. Leon & M. Leszek (Eds.). Germany: Wiley-VCH.

Leroy, A., Ribeiro, S., Grossiord, C., Alves, A., Vestberg, R. H., Salles, V., Brunon, C., Gritsch, K., Grosgogeat, B., & Bayon, Y. (2017). FTIR microscopy contribution for comprehension of degradation mechanisms in PLA-based implantable medical devices. *J Mater Sci Mater Med, 28*(6), 87

Li, C., Hou, J., Huang, Z., Zhao, T., Xiao, L., Gao, G., Harnoode, C., & Dong, A. (2015). Assessment of 2,2,6,6-tetramethyl-4-piperidinol-based amine Nhalamine-labeled silica nanoparticles as potent antibiotics for deactivating bacteria. *Colloids Surf B Biointerfaces, 126*, 106-114

Li, X., Wang, C., Fei, L., Lili, Z., Qiang, Y., Jing, M., & Xinhua, L. (2015). Physicochemical properties of corn starch isolated by acid liquid and L-cysteine. *Food Hydrocolloids, 44*, 353-359

Linyao, Z., Guiyan, Z., & Wei, J. (2016). Mechanical properties of biodegradable polylactide/poly(ether-block-amide)/thermoplastic starch blends: Effect of the crosslinking of starch. *Journal of Applied Polymer Science*, 1-7

Liu, H., Xie, F., Yu, L., Chen, L., & Li, L. (2009). Thermal processing of starch-based polymers. *Progress in Polymer Science, 34*, 1348–1368

Lomeli-Ramirez, M. G., Kestur, S. G., Manriquez-Gonzalez, R., Iwakiri, S., de Muniz, G. B., & Flores-Sahagun, T. S. (2014). Bio-composites of cassava starch-green coconut fiber: part II-Structure and properties. *Carbohydr Polym, 102*, 576-583

Lopes, L. Q., Santos, C. G., Gende, L., Raffin, R. P., de Almeida Vaucher, R., & Santos, R. C. (2016). Evaluation of antimicrobial activity of glycerol monolaurate nanocapsules against American foulbrood disease agent and toxicity on bees. *Microb Pathog, 97*, 183-188

López, O., Castillo, L., Zaritzky, N., Barbosa, S., Villar, M., & García, M. A. (2015). Talc Nanoparticles Influence on Thermoplastic Corn Starch Film Properties. *Procedia Materials Science, 8*, 338-345

Lopez, O., Garcia, M. A., Villar, M. A., Gentili, A., Rodriguez, M. S., & Albertengo, L. (2014). Thermo-compression of biodegradable thermoplastic corn starch films containing chitin and chitosan. *LWT - Food Science and Technology, 57*(1), 106-115

Lu, D. R., Xiao, C. M., & Xu, S. J. (2009). Starch-based completely biodegradable polymer materials. *Express Polymer Letters, 3*(6)

Lu, Z., Dang, W., Zhao, Y., Wang, L., Zhang, M., & Liu, G. (2017). Toward high-performance poly(para-phenylene terephthalamide) (PPTA)-based composite paper via hot-pressing: the key role of partial fibrillation and surface activation. *RSC Advances, 7*(12), 7293-7302

Lucera, A., Conte, A., & Del Nobile, M. A. (2016). Volatile Compounds Usage in Active Packaging Systems. 319-327

Madivoli, E. S., Gitu, L., & Gumba, M. E. (2012). Isolation And Identification Of Essential Oils From Cymbopogan Citratus (Stapf) Dc Using Gc-Ms And Ft-Ir. *Chemistry and Materials Resear, 2*(4), 13-24

Mahieua, A., Terriéa, B. C., & Youssef, B. (2015). Thermoplastic starch films and thermoplasti oxygen scavenging Influence of water content. *Industrial Crops and Products, 72*, 192–199

Maizura, M., Fazilah, A., Norziah, M. H., & Karim, A. A. (2007). AntibacterialActivity andMechanical Properties of PartiallyHydrolyzed Sago Starch–Alginate Edible FilmContaining LemongrassOil. *Journa of Food Science, 72*(6)

Malhotra, B., Keshwani, A., & Kharkwal, H. (2015). Antimicrobial food packaging: potential and pitfalls. *Front Microbiol, 6*(611), 1-9

Mali, S., Sakanaka, L. S., Yamashita, F., & Grossmann, M. V. E. (2005). Water sorption and mechanical properties of cassava starch films and their relation to plasticizing effect. *Carbohydr Polym, 60*(3), 283-289

Maran, J. P., Sivakumar, V., Sridhar, R., & Thirugnanasambandham, K. (2013). Development of model for barrier and optical properties of tapioca starch based edible films. *Carbohydr Polym, 92*(2), 1335-1347

Maree, J., Kamatou, G., Gibbons, S., Viljoen, A., & Van Vuuren, S. (2014). The application of GC–MS combined with chemometrics for the identification of antimicrobial compounds from selected commercial essential oils. *Chemometrics and Intelligent Laboratory Systems, 130*, 172-181

Martin, A. H., Ferrer, A., Tyagi, P., Yin, Y., Salas, C., Pal, L., & Rojas, O. J. (2017). Nanocellulose in Thin Films, Coatings, and Plies for Packaging Applications: A Review. *BioResources, 12*(1), 2143-2233

Martin, O., & Averous, L. (2001). Poly(lactic acid): plasticisation and properties of bidegradable multiphase systems. *Polymer, 42*, 6209-6219

Martina, S. d. L., & Giovanni, F. (2016). Effects of nanoparticles on the morphology of immiscible polymer blends Challenges and opportunities. *European Polymer Journal, 79*, 198–218

Martins, A. B., & Santana, R. M. (2016). Effect of carboxylic acids as compatibilizer agent on mechanical properties of thermoplastic starch and polypropylene blends. *Carbohydr Polym, 135*, 79-85

Martucci, J. F., Gende, L. B., Neira, L. M., & Ruseckaite, R. A. (2015). Oregano and lavender essential oils as antioxidant and antimicrobial additives of biogenic gelatin films. *Industrial Crops and Products, 71*, 205-213

Masmoudi, F., Atef, B., Mohamed, D., Jaziri, M., & Emna, A. (2016). Biodegradable packaging materials conception based on starch and polylactic acid (PLA) reinforced with cellulose. *Environ Sci Pollut Res*, 1-11

McKeen, L. W. (2012). *Introduction to Plastics and Polymers*: Elsevier Inc.

Medina, J. C., Gutierrez, T. J., Goyanes, S., Bernal, C., & Fama, L. (2016). Biodegradability and plasticizing effect of yerba mate extract on cassava starch edible films. *Carbohydr Polym, 151*, 150-159

Mehyar, G. F., & Han, J. H. (2006). Physical and Mechanical Properties of High-amylose Rice and Pea Starch Films as Affected by Relative Humidity and Plasticizer. *Journal of Food Science*, 1-7

Meimoun, J., Wiatz, V., RenSaint-Loup, Parcq, J., Favrelle, A., Bonnet1, F., & Zinck, P. (2017). Modification of Starch graft copolymerization. *Starch - Stärke, 69*, 1-23

Menard, K. P. (1999). *Dynamic mechanical analysis, A Practical Introduction*. United States of America: CRC Press.

Menner, A. S. M. (1996). Assessment of Biodegradability of Plastics under Simulated Cornposting Conditions in a Laboratory Test System. *International Biodeterioration and Biodegradation*, 85-92

Menzel, C., Olsson, E., Plivelic, T. S., Andersson, R., Johansson, C., Kuktaite, R., Jarnstrom, L., & Koch, K. (2013). Molecular structure of citric acid cross-linked starch films. *Carbohydr Polym, 96*(1), 270-276

Mesias, R., & Murillo, E. (2018). Hyperbranched polyester polyol modified with polylactic acid as a compatibilizer for plasticized tapioca starch/polylactic acid blends. *Polímeros, 28*(1), 44-52

Mir, S. A., Shah, M. A., Naik, H. R., & Zargar, I. A. (2016). Influence of hydrocolloids on dough handling and technological properties of gluten-free breads. *Trends in Food Science & Technology, 51*, 49-57

Miranda, J. M., Mondragón, A. C., Lamas, A., Roca-Saavedra, P., Ibarra, I. S., Rodriguez, J. A., Cepeda, A., & Franco, C. M. (2016). Effect of Packaging Systems on the Inactivation of Microbiological Agents. 107-116

Mistler, R. E., & Twiname, E. R. (2000). *Tape Casting: Theory and Practice*: Wiley.

Mittal, V., Akhtar, T., & Matsko, N. (2015). Mechanical, Thermal, Rheological and Morphological Properties of Binary and Ternary Blends of PLA, TPS and PCL. *Macromolecular Materials and Engineering, 300*(4), 423-435

Mlalila, N., Hilonga, A., Swai, H., Devlieghere, F., & Ragaert, P. (2018). Antimicrobial packaging based on starch, poly(3-hydroxybutyrate) and poly(lactic-co-glycolide) materials and application challenges. *Trends in Food Science & Technology, 74*, 1-11

Mohammadi, N. A., Moradpour, M., Saeidi, M., & Alias, A. K. (2013). Thermoplastic starches: Properties, challenges, and prospects. *Starch - Stärke, 65*(1-2), 61-72

Müller, C. M. O., Laurindo, J. B., & Yamashita, F. (2009). Effect of cellulose fibers addition on the mechanical properties and water vapor barrier of starch-based films. *Food Hydrocolloids, 23*(5), 1328-1333

Müller, C. M. O., Pires, A. T. N., & Yamashita, F. (2012). Characterization of Thermoplastic Starch/Poly(Lactic Acid) Blends Obtained by Extrusion and Thermopressing. *J. Braz. Chem. Soc.,, 23*(3), 426-443

Muller, J., González-Martínez, C., & Chiralt, A. (2017). Poly(lactic) acid (PLA) and starch bilayer films, containing cinnamaldehyde, obtained by compression moulding. *European Polymer Journal, 95*, 56-70

Müller, P., Bere, J., Fekete, E., Moczo, J., Nagy, B., Kally, M., Gyarmati, B., & Pukanszky, B. (2016). Interactions, structure and properties in PLA plasticized starch blends. *Polymer, 103*, 9-18

Müller, P., Imre, B., Bere, J., Móczó, J., & Pukánszky, B. (2015). Physical ageing and molecular mobility in PLA blends and composites. *Journal of Thermal Analysis and Calorimetry*, *122*(3), 1423-1433

Muller, P., Kapin, E., & Fekete, E. (2014). Effects of preparation methods on the structure and mechanical properties of wet conditioned starch/montmorillonite nanocomposite films. *Carbohydr Polym, 113*, 569-576

Muriel-Galet, V., Cran, M. J., Bigger, S. W., Hernández-Muñoz, P., & Gavara, R. (2015). Antioxidant and antimicrobial properties of ethylene vinyl alcohol copolymer films based on the release of oregano essential oil and green tea extract components. *Journal of Food Engineering*, *149*, 9-16

Muthui, Z. W., Kamweru, P. K., Nderitu, F. G., Hussein, S. A. G., Ngumbu, R., & Njoroge, G. N. (2015). Poly lactic acid viscoelastic properties and their degradation compared with those of polyethylene. *International Journal of Physical Sciences, 10*(2), 568-575

Nafchi, A. M., Moradpour, M., Saeidi, M., & Alias, A. K. (2013). Thermoplastic starches: Properties, challenges, and prospects. *Starch/Stärke, 65*, 61-72

Naik, M. I., Fomda, B. A., Jaykumar, E., & Bhat, J. A. (2010). Antibacterial activity of lemongrass (Cymbopogon citratus) oil against some selected pathogenic bacterias. *Asian Pacific Journal of Tropical Medicine*, 535-538

Nasri-Nasrabadi, B., Behzad, T., & Bagheri, R. (2014). Preparation and characterization of cellulose nanofiber reinforced thermoplastic starch composites. *Fibers and Polymers, 15*(2), 347-354

NatureWorks-LLC. (2015). Sheet-Extrusion Processing Guide. 1-8

Nawapat, D., & Thawien, W. (2013). Effect of UV-treatment on the properties of biodegradable rice starch films. *International Food Research Journal, 20*(3), 1313-1322

NCCLS. (2003). Susceptibility Testing of Mycobacteria, Nocardiae, and Other Aerobic Actinomycetes; Approved Standard. *M24-A, 23*(18)

Nezamzadeh, S. A., Ahmadi, Z., & Taromi, F. A. (2017). From microstructure to mechanical properties of compatibilized polylactide/thermoplastic starch blends. *Journal of Applied Polymer Science*, 1-9

Nossa, T. S., Belgacem, N. M., Gandini, A., & Carvalho, A. J. F. (2015). Thermoreversible crosslinked thermoplastic starch. *Polymer International, 64*(10), 1366-1372

Nur Ain, A. H., Zaibunnisa, A. H., Halimahton Zahrah, M. S., & Norashikin, S. (2013). An experimental design approach for the extraction of lemongrass (Cymbopogon citratus) oleoresin using pressurised liquid extraction (PLE). *International Food Research Journal, 20*(1), 451-455

Nurzyńska-Wierdak, R., Bogucka-Kocka, A., & Szymczak, G. (2014). Volatile constituents of Melissa officinalis leaves determined by plant age. *Nat Prod Commun., 9*(5), 703-706

Ojeda, J. s. J., & Maria, D. (2012). Fourier Transform Infrared Spectroscopy for Molecular Analysis of Microbial Cells. *Methods in Molecular Biology,, 881*, 187-213

Olivato, J. B., Grossmann, M. V. E., Bilck, A. P., & Yamashita, F. (2012). Effect of organic acids as additives on the performance of thermoplastic starch/polyester blown films. *Carbohydr Polym, 90*(1), 159-164

Olivato, J. B., Grossmann, M. V. E., Yamashita, F., Eiras, D., & Pessan, L. A. (2012). Citric acid and maleic anhydride as compatibilizers in starch/poly(butylene adipate-co-terephthalate) blends by one-step reactive extrusion. *Carbohydr Polym, 87*(4), 2614-2618

Olivato, J. B., Müller, C. M. O., Yamashita, F., Grossmann, M. V. E., & Nobrega, M. M. (2013). Study of the compatibilizer effect in the properties of starch / polyester blends. *Polímeros Ciência e Tecnologia, 23*(3), 346-351

Olsson, E., Hedenqvist, M. S., Johansson, C., & Jarnstrom, L. (2013). Influence of citric acid and curing on moisture sorption, diffusion and permeability of starch films. *Carbohydr Polym, 94*(2), 765-772

Ortega-Toro, R., Muñoz, A., Talens, P., & Chiralt, A. (2016). Improvement of properties of glycerol plasticized starch films by blending with a low ratio of polycaprolactone and/or polyethylene glycol. *Food Hydrocolloids, 56*, 9-19

Otgonzul, O. (2010). *Bioactive polymeric systems for food and medical packaging applications.* (Ph.D Doctoral Thesis), Tomas Bata University, Zlin, Czech Republic.

Pallab, D., & Pankaj, T. (2017). Thermal degradation kinetics of plastics and model selection. *Thermochimica Acta, 654* 191–202

Park, J. W., Im, S. S., Kim, S. H., & Kim, Y. H. (2000). Biodegradable Polymer Blends of Poly(L-actic acid) and Gelatinized Starch. *Polymer Engineering and Sciece, 40*(12), 2539-2551

Peelman, N., Ragaerta, P., Meulenaer, B. D., Adons, D., Peeters, R., Ludwig Cardond, Impe, F. V., & Devlieghere, F. (2013). Application of bioplastics for food packaging. *Food Science and Technology, 32*, 128-141

Pérez-Pérez, C., Regalado-González, C., Barbosa-Rodríguez, J. R., Rodríguez-Rodríguez, C. A., & Villaseñor-Ortega, F. (2006). Incorporation of antimicrobial agents in food packaging films and coatings. *Advances in Agricultural and Food Biotechnology, 2006:*, 193-216

Pervaiz, M., Oakley, P., & Sain, M. (2014). Extrusion of Thermoplastic Starch: Effect of "Green" and Common Polyethylene on the Hydrophobicity Characteristics. *Materials Sciences and Applications, 05*(12), 845-856

Peter, J. G., John, H., & Richard, B. (2001). *Electron Microscopy and Analysis* (Third edition ed.): Taylor and Francis.

Pizzoli, A. P. d. O., Yamashita, F., Gonçalves, O. H., Shirai, M. A., & Leimann, F. V. (2017). The effect of gelatin amount on the properties of PLA/TPS/gelatin extruded sheets. *Polímeros, 27*(1), 27-34

Prasad, P., & Kochhar, A. (2014). Active Packaging in Food Industry: A Review. *IOSR Journal of Environmental Science, Toxicology and Food Technology, 8*(5), 1-7

Priyaa, B., Guptab, V. K., Pathaniab, D., & Singhac, A. S. (2014). Synthesis, characterization and antibacterial activity of biodegradable starch PVA composite films reinforced with cellulosic fibre. *Carbohydr Polym, 109*, 171–179

Pushpadass, H. A., Marx, D. B., Wehling, R. L., & Hanna, M. A. (2009). Extrusion and Characterization of Starch Films. *Cereal Chemistry Journal, 86*(1), 44-51

Raeisi, M., Tajik, H., Yarahmadi, A., & Sanginabadi, S. (2015). Antimicrobial Effect of Cinnamon Essential Oil Against Escherichia Coli and Staphylococcus aureus. *Health Scope, 4*(4)

Ramírez, M. G. L., Muniz, G. I. B. d., Satyanarayana, K. G., Tanobe, V., & Iwakiri, S. (2010). Preparation and characterization of biodegradable composites based on Brazilian cassava starch, corn starch and green coconut fibers. *Revista Matéria,, 15*(2), 330-337

Ramirez, N. V., Sanchez-Soto, M., Illescas, S., & Gordillo, A. (2009). Thermal Degradation of Polyoxymethylene Evaluated with FTIR and Spectrophotometry. *Polymer-Plastics Technology and Engineering,, 48*, 470–477

Ranitha, M., Nour, A. H., Sulaiman, Z. A., Nour, A. H., & Thana Raj, S. (2014). A Comparative Study of Lemongrass (Cymbopogon Citratus) Essential Oil Extracted by Microwave-Assisted Hydrodistillation (MAHD) and Conventional Hydrodistillation (HD) Method. *International Journal of Chemical Engineering and Applications, 5*(2), 104-108

Rasal, R. M., Janorkar, A. V., & Hirt, D. E. (2010). Poly(lactic acid) modifications. *Progress in Polymer Science, 35*(3), 338-356

Ratnayake, W. S., Hoover, R., & Warkentin, T. (2002). Pea Starch: Composition, Structure and Properties – A Review. *Starch/Stärke, 54*, 217–234

Ray, S. S., & Masami, O. (2003). Biodegradable Polylactide and Its Nanocomposites: Opening a New Dimension for Plastics and Composites. *Macromol. Rapid Commun., 24*, 815-840

Richard, A. G., & Kalra, B. (2017). Biodegradable polymers for the environment. *sciencemag.org, 297*

Rindlav, A., H.D., S., Hullernan, & Gatenholm, P. (1997). Formation of starch films with varying crystallinity *Carbohydr Polym, 34* 25-30

Robert, S., & Ing, K. (2012). Thermoplastic Starch. In P. A. El-Sonbati (Ed.), *Thermoplastic Elastomers*. Crotia: In Tech.

Rocha, M., Ferreira, F. A., Souza, M. M., & Prentice, C. (2013). Antimicrobial films: a review. *Formatex*, 23-32

Rodriguez-Gonzalez, F. J., Ramsay, B. A., & Favis*, B. D. (2004). Rheological and thermal properties of thermoplastic starch with high glycerol content. *Carbohydr Polym, 58*, 139-147

Rodrıguez, A., Batlle, R., & Nerin, C. (2007). The use of natural essential oils as antimicrobial solutions in paper packaging. Part II. *Progress in Organic Coatings, 60*, 33–38

Rooney, M. (1995). Overview of active food packaging. In R. ML (Ed.), *Active food packaging*. Glasgow: Blackie Academic & Professional

Roshafima, R. A., AbdulRahman, W. A. W., Kasmani, R. M., & Ibrahim, N. (2012). Starch Based Biofilms-for-Green-Packaging. *World Academy of Science, Engineering and Technology, 6*, 508-513

Rostami, H., Kazemi, M., & Shafiei, S. (2012). Antibacterial activity of Lavandula officinalis and Melissa officinalis against some human pathogenic bacteria. *Asian Journal of Biochemistry, 7*(3), 133-142

Salvia-Trujillo, L., Rojas-Graü, A., Soliva-Fortuny, R., & Martín-Belloso, O. (2015). Physicochemical characterization and antimicrobial activity of food-grade emulsions and nanoemulsions incorporating essential oils. *Food Hydrocolloids, 43*, 547-556

Sánchez-González, L., Cháfer, M., Hernández, M., Chiralt, A., & González-Martínez, C. (2011). Antimicrobial activity of polysaccharide films containing essential oils.

Sanyang, M. L., Sapuan, S. M., Jawaid, M., Ishak, M. R., & Sahari, J. (2016). Effect of plasticizer type and concentration on physical properties of biodegradable films based on sugar palm (arenga pinnata) starch for food packaging. *J Food Sci Technol, 53*(1), 326-336

Schmitt, H., Guidez, A., Prashatha, K., Soulestin, J., Lacrampe, M. F., & Krawczak, P. (2015). Studies on the effect of storage time and plasticisers on the structural variations in thermoplastic starch. *Carbohydr Polym, 115*, 365-372

Schmitz, C. S., de Simas, K. N., Santos, K., Joao, J. J., de Mello Castanho Amboni, R. D., & Amante, E. R. (2006). Cassava starch functional properties by etherification - hydroxypropylation. *International Journal of Food Science and Technology, 41*(6), 681-687

Schultz, J. M. (2016). Overview and Prospects of Polymer Morphology *Polymer Morphology* (pp. 1-13): John Wiley & Sons, Inc.

Schultz, J. M. (2016). Overview and prospects of polymer morphology. In Q. Guo (Ed.), *Polymer Morphology Principles, Characterisation and Processing* (pp. 1-13). Hoboken, New Jersey, USA: JohnWiley & Sons, Inc., .

Seligra, P. G., Jaramillo, C. M., Fama, L., & Goyanes, S. (2016). Biodegradable and non-retrogradable eco-films based on starch-glycerol with citric acid as crosslinking agent. *Carbohydr Polym, 138*, 66-74

Seo, M.-K., Lee, J.-R., & Park, S.-J. (2005). Crystallization kinetics and interfacial behaviors of polypropylene composites reinforced with multi-walled carbon nanotubes. *Materials Science and Engineering: A, 404*(1-2), 79-84

Seo, M., Lee, J., & Park, S. (2005). Crystallization kinetics and interfacial behaviors of polypropylene composites reinforced with multi-walled carbon nanotubes. *Materials Science and Engineering: A, 404*(1-2), 79-84

Seow, Y. X., Yeo, C. R., Chung, H. L., & Yuk, H. G. (2014). Plant essential oils as active antimicrobial agents. *Crit Rev Food Sci Nutr, 54*(5), 625-644

Seydim, A. C., & Sarikus, G. (2006). Antimicrobial activity of whey protein based edible films incorporated with oregano, rosemary and garlic essential oils. *Food Research International, 39*, 639–644

Shirahase, T. K., Yoichi Tominaga,Yoichi Asai,Shigeo , & Masao, S. (2006). Miscibility and hydrolytic degradation in alkaline solution of poly(L-lactide) and poly(methyl methacrylate) blends. *Polymer, 47*, 4839–4844

Shirai, M. A., Grossmann, M. V., Mali, S., Yamashita, F., Garcia, P. S., & Muller, C. M. (2013). Development of biodegradable flexible films of starch and poly(lactic acid) plasticized with adipate or citrate esters. *Carbohydr Polym, 92*(1), 19-22

Shirai, M. A., Juliana, B. O., Maria, V. E. G., Ivo, M. D., Carmen, M. O., Müller, & Fabio, Y. (2016). Poly lactic acid and thermoplastic starch sheets: effect of adipate esters on the morphological mechanical and barrier properties. *Polímeros*

Shojaee-Aliabadi, S., Hosseini, H., Mohammadifar, M. A., Mohammadi, A., Ghasemlou, M., Hosseini, S. M., & Khaksar, R. (2014). Characterization of kappa-carrageenan films incorporated plant essential oils with improved antimicrobial activity. *Carbohydr Polym, 101*, 582-591

Shojaee-Aliabadi, S., Hosseini, H., Mohammadifar, M. A., Mohammadi, A., Ghasemlou, M., Ojagh, S. M., Hosseini, S. M., & Khaksar, R. (2013). Characterization of antioxidant-antimicrobial kappa-carrageenan films containing Satureja hortensis essential oil. *Int J Biol Macromol, 52*, 116-124

Silverajah, V. S., Ibrahim, N. A., Zainuddin, N., Yunus, W. M., & Hassan, H. A. (2012). Mechanical, thermal and morphological properties of poly(lactic acid)/epoxidized palm olein blend. *Molecules, 17*(10), 11729-11747

Smith, B. (1999). *Infrared Spectral Interpretation A Systematic Approach*: CRC Press LLC.

Sonkhaskar, Y. M., Choubey, A., Bhamra, A., Singhal, R., & Anurag, S. (2014). New-Design-Of-A-Plastic-Bottle-Crusher. *International journal of Scientific and Technoogy research, 3*(7), 61-63

Souza, A. C., Benze, R., Ferrão, E. S., Ditchfield, C., Coelho, A. C. V., & Tadini, C. C. (2012). Cassava starch biodegradable films: Inluence of glycerol and clay nanoparticles content on tensile and barrier properties and glass transition temperature. *Food Science and Technology, 46* 110-117

Stading, M. (1998). Dynamic Mechanical Analysis of Biopolymer Films. *Annual Transactions of The Nordic Rheology Society, 6*, 147-150

Su, Y.-l., Wang, J., & Liu, H.-z. (2002). FTIR Spectroscopic Study on Effects of Temperature and Polymer Composition on the Structural Properties of PEO-PPO-PEO Block Copolymer Micelles. *langmuir, 18*, 5370-5374

Suet-Yen, S., Sin, L. T., Tee, T.-T., Bee, S.-T., Rahmat, A. R., Rahman, W. A. W. A., Tan, A.-C., & Vikhraman, M. (2013). Antimicrobial agents for food packaging applications. *Trends in Food Science & Technology, 33*(2), 110-123

Sun, S., Liu, P., Ji, N., Hou, H., & Dong, H. (2017). Effects of low polyhydroxyalkanoate content on the properties of films based on modified starch acquired by extrusion blowing. *Food Hydrocolloids*, *72*, 81-89

Sung, C. T. B. (2017). Malaysians use 3 billion plastic shopping bags per year, so why is limiting or even banning their use still a grossly inadequate strategy http://www.christopherteh.com/blog/2017/02/malaysia-plastic-shopping-bags/.

Supanchaiyamat, N., Shuttleworth, P. S., Yue, H.-B., Fernandez-Blazquez, J. P., Budarin, V. L., Hunt, A. J., Sikhom, C., & Chaengkham, S. (2017). Bio-based carbonaceous composite materials from epoxidised linseed oil, bio-derived curing agent and starch with controllable functionality. *RSC Adv.*, *7*(7), 24282–22429

Suppakul, P. (2004). *study of Antimicrobial Polymeric packaging Films Containing Basil Extracts.* Victoria University.

Suppakul, P., Sonneveld, K., Bigger, S. W., & Miltz, J. (2011). Diffusion of linalool and methylchavicol from polyethylene-based antimicrobial packaging films. *LWT - Food Science and Technology, 44*(9), 1888-1893

Szymońska, J., Targosz-Korecka, M., & Krok, F. (2009). Characterization of starch nanoparticles. *Journal of Physics: Conference Series, 146*, 012027

Tako, M., Tamaki, Y., Teruya, T., & Takeda, Y. (2014). The Principles of Starch Gelatinization and Retrogradation. *Food and Nutrition Sciences, 05*(03), 280-291

Tapia-Blácido, D. R., do Amaral Sobral, P. J., & Menegalli, F. C. (2011). Optimization of amaranth flour films plasticized with glycerol and sorbitol by multi-response analysis. *LWT - Food Science and Technology*, *44*(8), 1731-1738

Tawakkal, I. S. M. A., Cran, M. J., & Bigger, S. W. (2016). Release of thymol from poly(lactic acid)-based antimicrobial films containing kenaf fibres as natural filler. *LWT - Food Science and Technology, 66*, 629-637

TC-WI. (2003). Chemical Analyses – Determination of dry matter and water content on a mass basis in sediment, sludge, soil, and waste – Gravimetric method.

Tegene, D. Z., Segne, T. A., & Chebude, Y. (2016). Synthesis and Characterization of Starch Vernolates in Organic Solvents. *American Journal of Applied Chemistry*, *4*(6), 212

Teixeira, E. d. M., Curvelo, A. A. S., Corrêa, A. C., Marconcini, J. M., Glenn, G. M., & Mattoso, L. H. C. (2012). Properties of thermoplastic starch from cassava bagasse and cassava starch and their blends with poly (lactic acid). *Industrial Crops and Products, 37*(1), 61-68

Tharazi, I., Sulong, A. B., Muhamad, N., Haron, C. H. C., Tholibon, D., Ismail, N. F., Radzi, M. K. F. M., & Razak, Z. (2017). Optimization of Hot Press Parameters on Tensile Strength for Unidirectional Long Kenaf Fiber Reinforced Polylactic-Acid Composite. *Procedia Engineering, 184*, 478-485

Thomas, S., Grohens, Y., & Jyotishkumar, P. (2015). *Characterization of Polymer blend* Singapore: Markono PrintMedia Pte Ltd.

Thunwall, M., Antal Boldizar, & Mikael, R. (2006). Compression Molding and Tensile Properties of Thermoplastic Potato Starch Materials. *Biomacromolecules, 7*, 981-986

Tong, S. Y., Lim, P. N., Wang, K., & Thian, E. S. (2018). Development of a functional biodegradable composite with antibacterial properties. *Materials Technology Advanced Performance Materials*, 1-7

Tongdeesoontorn, W., Mauer, L. J., Wongruong, S., Pensiri, S., & Pornchai, R. (2012). Mechanical and Physical Properties of Cassava Starch-Gelatin Composite Films. *International Journal of Polymeric Materials, 61*, 778–792

Trombetta, D., Saija, A., Bisignano, G., Arena, S., Caruso, S., Mazzanti, G., Uccella, N., & Castelli, F. (2002). Study on the mechanisms of the antibacterial action of some plant a,b-unsaturated aldehydes. *Letters in Applied Microbiology,, 35*, 285–290

Tsai, W. C., Hedenqvist, M. S., Laiback, Å., Melin, H., Ngo, M., Trollsås, M., & Gedde, U. W. (2016). Physical changes and sorption/desorption behaviour of amorphous and semi-crystalline PLLA exposed to water, methanol and ethanol. *European Polymer Journal, 76*, 278-293

Tsai, Y. C., Yu, M. L., El-Shazly, M., Beerhues, L., Cheng, Y. B., Chen, L. C., Hwang, T. L., Chen, H. F., Chung, Y. M., Hou, M. F., Wu, Y. C., & Chang, F. R. (2015). Alkaloids from Pandanus amaryllifolius: Isolation and Their Plausible Biosynthetic Formation. *J Nat Prod, 78*(10), 2346-2354

Turner, R. J. (2017). Metal-based antimicrobial strategies. *Microb Biotechnol, 10*(5), 1062-1065

Twiname, E. R., & Mistler, R. E. (2001). Tape Casting and Lamination. In K. H. J. Buschow, R. W. Cahn, M. C. Flemings, B. Ilschner, E. J. Kramer, S. Mahajan & P. Veyssière (Eds.), *Encyclopedia of Materials: Science and Technology* (pp. 9083-9088). Oxford: Elsevier.

UFAO. (2012). Cassava Production in Malaysia (United Nations Food and Agriculture) https://www.quandl.com/data/UFAO/CR_CASS_MYS-Cassava-Production-in-Malaysia.

Ullah, A., & Wu, J. (2012). Feather Fiber-Based Thermoplastics: Effects of Different Plasticizers on Material Properties. *Macromol. Mater. Eng*, 1-10

van-Soest, J. J. G., Hulleman, S. H. D., de-Wit, D., & Vilegenthart, J. F. G. (1996). Changes in the mechanical properties of thermoplastic potato starch in relation with changes in B-type crystallinity. *Carbohydr Polym, 29*, 225-232

Vermeiren, L., Devliegher, F., Van Beest, M., de Kruijf, N., & Debevere, J. (1999). Developments in the active packaging of foods. *Trends in Food Science & Technology, 10*, 77-86

Versino, F., López, O. V., & García, M. A. (2015). Sustainable use of cassava (Manihot esculenta) roots as raw material for biocomposites development. *Industrial Crops and Products, 65*, 79-89

Wang, L.-F., & Rhim, J.-W. (2016). Grapefruit seed extract incorporated antimicrobial LDPE and PLA films: Effect of type of polymer matrix. *LWT - Food Science and Technology, 74*, 338-345

Wang, N., Yu, J., Chang, P. R., & Ma, X. (2008). Influence of formamide and water on the properties of thermoplastic starch/poly(lactic acid) blends. *Carbohydr Polym, 71*(1), 109-118

Wang, N., Yu, J., & Ma, X. (2008). Preparation and characterization of compatible thermoplastic dry starch/poly(lactic acid). *Polymer Composites, 29*(5), 551-559

Wang, S., Zhang, X., Wang, S., & Copeland, L. (2016). Changes of multi-scale structure during mimicked DSC heating reveal the nature of starch gelatinization. *Sci Rep, 6*, 28271

Wang, Y., Zhang, L., Li, X., & Gao, W. (2011). Physicochemical Properties of Starches from Two Different Yam (Dioscorea Opposita Thunb.) Residues. *Braz. Arch. Biol. Technol, 54*, 243-251

Wang, Y., Zheng, Q., Li, W., Ma, Y., Zhao, X., & Zhang, C. (2018). Measurement of free water in foods by secondary derivative thermogravimetry. *Journal of food, 16*(1), 438–443

Waterschoot, J., Gomand, S. V., Fierens, E., & Delcour, J. A. (2015). Production, structure, physicochemical and functional properties of maize, cassava, wheat, potato and rice starches. *Starch - Stärke, 67*(1-2), 14-29

Wattanakornsiri, A., Pachana, K., Kaewpirom, S., Sawangwong, P., & Migliaresi, C. (2013). Green composites of thermoplastic corn starch and recycled paper cellulose fibers. *Songklanakarin J. Sci. Technol., 33*(4), 461-467

Wiegand, I., Hilpert, K., & Hancock, R. E. W. (2008). Agar and broth dilution methods to determine the minimal inhibitory concentration (MIC) of antimicrobial substances. *Nature Protocols, 3*, 163

Wittcoff, H. A., Reuben, B. G., & Plotkin, J. S. (2013). *Industrial Organic Chemicals* (Third Edition ed.). Hoboken, New Jersey: John Wiley & Sons, Inc.

Wu, S., Lv, G., & Lou, R. (2012). Applications of Chromatography Hyphenated Techniques in the Field of Lignin Pyrolysis.

Yan qun, L., De-xin, K., & Hong, W. (2013). Analysis and evaluation of essential oil components of cinnamon barks using GCMS and FTIR spectroscopy. *Industrial Crops and Products 41 (2013) 269– 278, 41*

Yang, Y., Tang, Z., Xiong, Z., & Zhu, J. (2015). Preparation and characterization of thermoplastic starches and theirblends with poly lactic acid. *Int J Biol Macromol, 77* 273–279

Yu, T., Jie, R., Shumao, L., Hua, Y., & Yan, L. (2010). Effect of fiber surface-treatments on the properties of poly(lactic acid)/ramie composites. *Composites Part B: Engineering, 41*, 499-505

Zain, A. H. M., Kahar, A. W. M., & Noriman, N. Z. (2016). Chemical-Mechanical Hydrolysis Technique of Modified Thermoplastic Starch for Better Mechanical Performance. *Procedia Chemistry, 19*, 638-645

Zainua, Z. A., & Songip, A. R. (2017). Policies, challenges and strategies for Municipal waste management in Malaysia. *JOSTIP, 3*(1), 18-23

Zhang, B., Fengwei, X., Tianlong, Z., Ling, C. L., Rowan, W. T., Peter, J. H., Julia, L. S., Tony, M., & Robin, D. R. (2016). Different characteristic effects of ageing on starch-based films plasticised by 1-ethyl-3-methylimidazolium acetate and by glycerol. *Carbohydr Polym, 146*, 67–79

Zhang, Y., Liu, X., Wang, Y., Jiang, P., & Quek, S. (2016). Antibacterial activity and mechanism of cinnamon essential oil against Escherichia coli and Staphylococcus aureus. *Food Control, 59*, 282-289

Zhang, Y., Liu, Z., & Han, J. (2008). Starch-based edible films *Environmentally compatible food packaging* (pp. 108-136). USA.

Zhang, Y., & Rempel, C. (2012). Retrogradation and Antiplasticization of Thermoplastic Starch.

Zhang, Y., Rempel, C., & Liu, Q. (2014). Thermoplastic starch processing and characteristics-a review. *Crit Rev Food Sci Nutr, 54*(10), 1353-1370

Zhen-Xiu, Z., Tao, Z., Xin, Z., Zhenxiang, X., Xu, D., & Prakashan, K. (2016). Mechanically stable superhydrophobic polymer films by a simple hot press lamination and peeling process. *RSC Advances, 6*(15), 12530-12536

Zhu, F. (2015). Review Composition structure physicochemical properties and modifications of cassava starch. *Carbohydr Polym, 122*, 456-480

Zia, K. M., Noreen, A., Zuber, M., Tabasum, S., & Mujahid, M. (2016). Recent developments and future prospects on bio-based polyesters derived from renewable resources: A review. *Int J Biol Macromol, 82* 1028–1040

Zullo, R., & Lannace, S. (2009). The effects of different starch sources and plasticizers on film blowing of thermoplastic starch: Correlation among process, elongational properties and macromolecular structure. *Carbohydrate Polymers,, 77*, 376–383